Study on Snake Robot Design for Investigating Rough Terrain

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Study on Snake Robot Design for Investigating Rough Terrain

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Abstract: *Robotics generally had to be the essential part of not industrial manufactures but humans daily life as well. Among of those, Snake robots are recently being researched as a new type of Robotic, interplanetary probe by engineers at the NASA Ames Research Center and being developed for search and rescue purposes at Carnegie Mellon University's Biorobotics Lab for their many applications. Some are capable of searching in dirty and dangerous environment that useful in natural disasters, rescues, fields of structures inspections, investigating rough terrain where it is dangerous for human and so on. In many cases, the actions involve risks and require high movement in the small space; we have to need a robot to do the dangerous works. In this paper, we demonstrate a work on building and developing a robot to mimic serpentine motion of snake that can transmit many information of current position through wireless RF to base station.*

Keywords: Robotics; Snake Robot; DHT (Digital Humidity Temperature Sensor); SRF(Sonar Range); DCO (Digitally Controlled Oscillator); ISM (Industrial, Scientific and Medical)

1. INTRODUCTION

The wheel is an amazing invention, but it does not roll everywhere. Wheeled mechanisms constitute the backbone of most ground-based means of transportation. On relatively smooth surfaces, such mechanisms can achieve high speeds and have good steering ability. Unfortunately, rougher terrain makes it harder, if not impossible, for such mechanisms to move. In nature, the snake is one of the creatures that exhibit excellent mobility in various terrains. It is able to move through narrow passages and climb on rough ground. This property of mobility is attempted recreated in robots that look and move like snakes. Snake robots most often have a high number of degrees of freedom (DOF) and they are able to locomote without using active wheels or legs.[1]

Snake robots suit a wide range of applications. One of many examples is rescue missions in earthquake areas. The snake could crawl through destroyed buildings looing for people. It could also carry small amounts of food or water to people trapped by the building prior to the arrival of rescue personnel. The snake robot can also be used for surveillance and maintenance of complex and possible dangerous structures such as nuclear plants or pipelines. In a city, it could inspect the sewer system looking for leaks or aiding fire fighters. In additionally, snake robots with on end fixed to a base maybe used as a robot manipulator which can reach hard-to –get-to places. [1][2]

Planning and control for a redundant locomotor, however, is difficult because one must coordinate all of the internal degrees of freedom of the robot to simultaneously provide locomotive benefit and direct the robot in a desired direction. Our approach uses a variety of motion primitives (gaits) [3][4] which we control online to direct the robots' motion. A subtle problem associated with defining primitives for limbless locomotors has to do with assigning the mechanism a body frame. [2]

2. BIOLOGICAL SNAKES AND INCHWORMS LOCOMOTION

Biological snakes, inchworms and caterpillars are the source of inspiration for most of the robots dealt with in this paper. Now we therefore focus more on bio-inspired imitative movements.

There several locomotions that are the source of inspiration for Snake robots such as: *Lateral undulation; Rectilinear locomotion; Sidewinding locomotion; Concertina motion* and other Snake gaits. In this paper, we did build our robot based on *Concertina motion.*

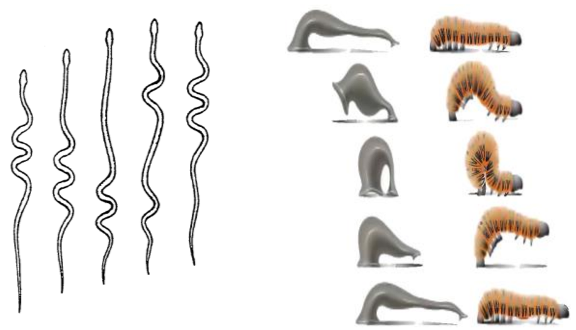


Fig. 1. Concertina motion

2.1 Concertina motion

A concertina is a small accordion instrument. The name is used in snake locomotion to indicate that the snake stretches and curves its body to move forward. The folded part is kept at a fixed position while the rest of the body is either pushed or pulled forward as shown in Fig. 1. Then, the two parts switch roles. Forward motion is obtained when the force needed to push back the fixed part of the snake body is higher than the friction forces on the moving part of the body.

Concertina locomotion is employed when the snake moves through narrow passages such as pipes or along branches. If the path is too narrow compared to the diameter and curving capacity of the snake, the snake is unable to locomote.[2]

2.2 Design and Mathematical Modeling

The key to snake robot locomotion is to continuously to change the shape of the robot. This is achieved by rotation and/or elongation of its joints. In [5][6] both present kinematic approaches on how to link the changes in internal configuration to the net position change of the robot. The relation is found by utilizing nonholonomic constraints and differential geometry such as connections. In [6] employs Hirose's Active Cord mechanism Model 3 (ACM II). The first three pair of wheels of ACM III are illustrated in Fig. 2. The five joint angles $\varphi 1$, $\varphi 2$, $\varphi 3$, $\psi 1$, and $\psi 3$ are controlled inputs. The kinematic nonholonomic constraints are realized by adding passive caster wheels on the snake robot and may be written in the form

$$\dot{x}_i \sin(\varphi_i) - \dot{y}_i \cos(\varphi_i) = 0$$

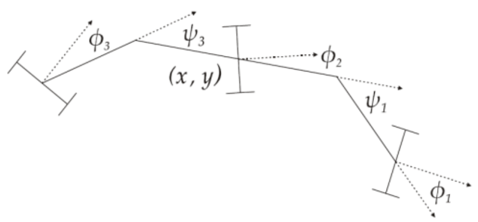


Fig.2. The first three links of the ACM III [6]

where ($\dot{x}_i$, $\dot{y}_i$) is the velocity of the center of mass and φ_i is the angle of the joint which the wheels are attached to.

3. MODEL BUILDING

Based on Concertina motion of the snake, we contruct our servomotor to implement the snake model as Fig. 3a,b

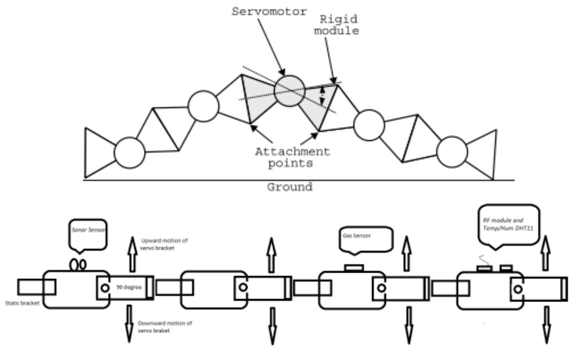


Fig. 3 (a) Concertina model building and (b) sensors included

The sequences of the Snake movement can be demonstrated as Fig. 4

4. CONTROL AND FUNCTIONAL FEATURES WITH SENSORS

The main controller for the Snake is two 16-bit TI MSP430G2452 ulte-low-power consumption

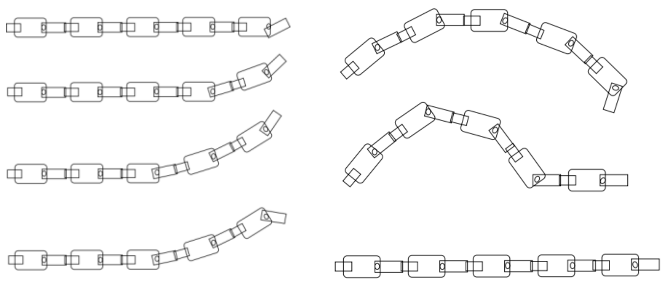
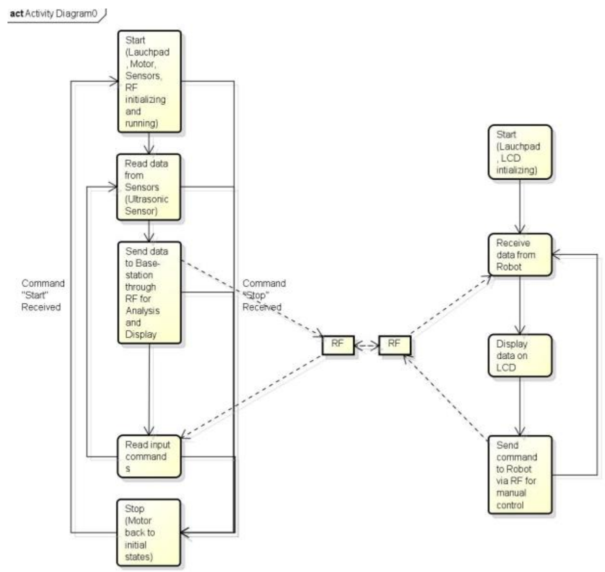


Fig. 4. Visualize the Snakes' motion

microcontroller, it has up to 24 I/O capacitive touch enabled pins. One is attached on Snakes' body, the another plays as the base station that will receive signals from: Ultrasonic range sensor (SRF05) for distance and object detection; CO detecting sensor (MQ-&) for gas detection; Temperature and Humidity sensor that can inform exact condition of the environment surrounded. Those signals will be sent wirelessly using RF to UART HC-11. All of these signal can be displayed in LCD screen.



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